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EDUCATION BY AUTHORITY OR FOR AUTHORITY? ARE SCIENCE TEACHERS TEACHING SCIENCE?[1]

By Professor OTIS F. CURTIS

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I FIND it rather difficult to discuss the teaching of science as I wish to discuss it without first discussing some of the more general aspects of teaching and education. So perhaps by way of introduction we should first consider the question as to what constitutes an education and what are to be its aims. This may be a controversial topic, but it is necessary to formulate at least tentative objectives before one can effectively discuss attainment or methods.

With some of the many subjects taught in the elementary schools, as well as in the trade and technical schools, the answer as to purpose and accomplishment may seem relatively obvious. The pupil learns to read, to write and to do simple problems in arithmetic. He obtains information and rules that he uses in daily routine. But in increasingly large numbers, young people are taking high-school and college subjects for, as they say, their "general educational or cultural values," not fitting themselves specifically for a vocation or trade. But why should a high percentage of the population study higher mathematics, ancient languages, modern languages, English literature, history, economics, chemistry, physics, geology, botany, zoology, etc.? Are these subjects or fields of general educational or cultural value? If so, why? And are they of equal value? Is a man educated or cultured because he has spent one to four years in studying or can read or speak a half dozen or more languages? Is he educated because he can solve intricate problems in mathematics, or can determine the chemical composition of a rock or a plant, or can synthesize some important compound? Is he educated because he can

[1] Condensed from the address of the retiring president of the American Society of Plant Physiologists, at Richmond, Va., December 28, 1938.

accurately describe the structural minutiae of a cat or a corn plant?

To some people an individual is considered educated if he has had a certain amount of formal schooling in any subject. Each of us, however, can call to mind several individuals who have had extensive and intensive formal schooling, but whom we should not consider as soundly or broadly educated. Probably no one subject is peerless as a subject for educational purposes, because we can find no relation between the subject of one's specialty and what we might consider his standard of educational attainment.

I doubt if we can agree as to what subjects are best for a general education, or even as to what constitutes an education; unless we agree that mere attendance at school for a given number of years will insure an education. Nevertheless, let us try to formulate an objective which, although it may fall short of what one might wish to include, still is not beyond hope of attainment. I think we can agree that the training of a person, if he is to be considered broadly educated, should be such as to give him understanding of himself, of the world about him and of his relationship to that world. It should give a foundation for further advancement and an ability to appreciate values and distinguish between the true and the false. It should prepare him to live with satisfaction in the present world; to meet without panic and without prejudice various problems as they arise; and he should be able not only to grow with, but also to help in improving, a growing world and changing civilization.

Our present civilization has developed the extensive school system which to-day gives an opportunity for large numbers of individuals to take advantage of the knowledge and experience of their contemporaries as well as their predecessors. In this school system are offered courses over a wide range of subjects and at levels suited to almost any age and ability. In the secondary schools, colleges and universities there are made available to students a vast array of courses for giving special training in almost any field one could wish to study. It seems surprising, however, that, of the students from these schools, so many of them seem to lack just what one would expect educated people to possess. They have such strong prejudices, political prejudices, social, religious, class and racial prejudices. They are so easily influenced and controlled by slogans, by propaganda and by dogma. They are so lacking in critical judgment, in poise, and so little given to looking for, and critically evaluating the evidence on both sides of a question. In fact, it often seems that people who have had a formal education are likely to have stronger prejudices, are less eager or less willing to hear both sides of a question than are those with less schooling. They are often more smug, more self-satisfied and less reasonable. This may be due to the fact that their training has made them complacent by giving them a false confidence and over-assurance. It has failed to make them more cautious and more humble. In short, it has failed to give them understanding. That it has failed in giving understanding is indicated by evidence of many sorts. For example, large numbers of our people, although they have literally spent years in school and are also exposed on all sides to developments of astronomy and related sciences, and have thus had opportunities far beyond those available even to the most privileged of a few generations ago, yet they believe in astrology and are swayed by the most impossible beliefs and superstitions as regards the influence of the stars on their individual lives. It is a disgrace to our civilization that it has gone so far in science as to develop the radio, and yet one can hear over this same radio the drivel of so-called "professors of astrology" whose pronouncements are on a level of thought comparable to that of primitive peoples or those of ancient or medieval times who had no contact with scientific method or thought.

It seems strange that in this day and age states can pass laws against the study or teaching of evolution: that other states can pass laws dictating what can be presented in books on history (to say nothing of the complete control over all fields of teaching as is practiced in many foreign countries); that laws are passed prohibiting the discussion of communism in schools: that states with the richest and perhaps the best-developed school systems in the world can pass or nearly pass ridiculous and even vicious laws. In the past two decades legislatures have passed or nearly passed laws against sanitation, against vaccination and against scientific investigation with living organisms. In such states with these richly supported school systems there are strongly organized groups of Anti-vivisectionists, Anti-evolutionists, Theosophists, Faith Healers, New Thoughtists, etc. It is my impression, though I have seen no data, that a high proportion of the people that make up these groups are from the so-called "more educated" classes. There are some grains of truth in the propositions of most of these organizations, but their adherents go to the greatest extremes and appear entirely lacking in understanding and in common sense, in judgment and in ability to evaluate critically. They fail to distinguish truth from the partly true or the false, to recognize values; and yet these people, many of them, have had the opportunities of higher education, including college and graduate schooling.

Not many years ago a professor in a university of high standing, a professor in a science department, let his son die of appendicitis without even consulting a physician. He knew there was something wrong

with his son, but he had become a Faith Healer. When asked by a doctor why he had not called in a physician when his child was in such a condition he replied, "Even you doctors sometimes lose your cases." There is no doubt but that one's mental attitude may have a great influence on his health, but one must use judgment as to when certain rules of procedure apply and when they are not adequate. This man's education, although it was in a so-called science subject, had not gone deep enough to enable him to recognize that one individual can not cure appendicitis in another by thinking high thoughts or by refusing to recognize acute and obvious signs of physical ill-health. It is true of course that many individuals imagine symptoms where none exist and may thus, through nervous control, actually bring on physical disturbances. But why go to such extremes? An educated person should be capable of using judgment and not merely blindly follow rules. Another professor with a national reputation in the field of economics, one who has had a fair amount of training in science, not long ago made the statement that "Vaccination and serum treatments are all bunkum." Within a few years I have received chain letters from two men, each holding the degree of doctor of philosophy. Each letter promised good luck if forwarded, and bad luck if the chain was allowed to be broken. The superstitious fears of these doctors of philosophy made them uneasy or perhaps even afraid to break the chain. No doubt each of you can think of comparable cases of individuals who have had extensive schooling but who seem to fail to show understanding or even "common sense." The medicine man, the believer in witchcraft and the voodoo priest are practicing right in our midst to-day, although they call themselves by more high-sounding names.

Is this failure of so-called educated people to come up to the standards we wish and have a right to expect, is this due to the weakness of the students themselves? Is it due to the failure to give training in the proper subjects? Is it due to incompetence of the teachers? Is it perhaps due to the fact that teachers may be placing the emphasis in the wrong place, that is, to wrong methods in teaching?

As for this matter of the method of teaching, a fact which has not been sufficiently recognized in some of our educational institutions is that there is often very little of the so-called transfer of training. That is, a very thorough training in one subject does not make one better able to judge in another, except in so far as the two have points in common, and it is often necessary that these points be very similar. I was talking with an Englishman who had just received his degree of doctor of philosophy in botany from a leading English university. His sister was going to India as a missionary. I asked him what her subject of specialization was and he said, "French; it makes no difference what subject she takes so long as she gets an education." But one may wonder what relation a training in French literature and language would have to missionary work in India. It is true that educators in recent years have been emphasizing this lack of transfer of training, but it seems that in many departments of education, instead of teaching a few basic courses in such a manner as to favor transfer, they merely multiply courses. By so doing they hope to give specific information on methods of teaching each and every subject a teacher may wish to teach. To obtain a teacher's certificate in some states it seems more important that the prospective teacher has a separate course in the method of teaching each subject to be taught than that he has thorough knowledge in the subject he proposes to teach.

To me this trend is entirely in the wrong direction. No schooling can ever hope to give the answers to all the problems that might arise, whether they be problems in teaching or in any other field. I am of the opinion that there is much more transfer of the right sort than is commonly recognized. I have reference to one's attitude or method of approach to a problem in hand; that is, approach with an open mind, without prejudice; an attempt to ascertain all possible facts bearing on the matter; a search for opposing evidence; a critical weighing of the evidence; a recognition of what constitutes evidence; a readiness to recognize possible complexities and contradictory evidence; and perhaps that all the evidence is not yet at hand. Such training in critical method may be given in many different subjects and fields. But much of the schooling even in colleges and universities is not of such a nature as to give this training.

Mathematics and ancient languages are often cited as "excellent for training the mind, tending to make one think clearly and accurately." It is true that to a certain extent mathematics does require a critical and analytical attitude, but its relation to everyday problems is often remote. In one sense mathematics may be too rigid and straightforward, too much given to rules and formulae, too exact for education towards a more satisfactory life, because the problems of living are not so definite as problems in mathematics. Mathematics starts with clearly verifiable assumptions or arbitrarily makes its own rules, and is therefore likely to lead to over-confidence when one comes to deal with subjects in which the premises themselves are questionable or indefinite.

This tendency toward over-confidence is often apparent in those who have had a formal schooling and introduces a serious problem in the field of teaching and education. The old saying "A little learning is a dangerous thing" has a real basis in fact. If one

acquired a smattering of information, especially if the teacher presented it with great confidence and an air of authority, with no cautions or qualifications and with no indications as to degree of certainty or uncertainty, an individual is likely to act on it without real understanding; whereas one without this superficial training feels less confident and is likely to be more cautious in acting. When trained dogmatically to follow directions or apply rules without understanding the underlying principles, there is always a danger of misapplying them, as did the professor who thought he could cure appendicitis in his son by mental treatments.

It seems that much of the training in our grade schools and high schools and even in universities is of this authoritative or dogmatic type. The pupil is not trained to think for himself, for the major emphasis is placed on learning so-called facts. Day by day, more and more information is drilled into the minds of our students. They are led to accept some text or individual as authority and are not encouraged to form their own opinions or to use their own judgment. However, to accept blindly the opinions and statements of others, to accept authority, does not lead to understanding by the pupil. In fact, the teacher who teaches authoritatively teaches answers, and is not helping the student to learn for himself or to arrive at a real understanding. Such a teacher is likely himself to accept authority from others, and the matter he presents tends to become more and more unrelated to the truth and to lose real significance. Vitality leaves a subject when it is carried on by authority, no matter what the subject.

In the minds of many people "teaching" and the indoctrination of dogma are synonymous. At least this appears to be the interpretation of many legislators when they pass laws prohibiting the discussion by teachers of evolution or of cummunism; or of private citizens who write denunciatory letters to school superintendents or college presidents if they hear that some teacher has discussed socialism, communism or evolution. To them a teacher's only function is dogmatically to instill doctrines or "facts" into the minds of pupils; to tell them *what* to think, not *how* to think. I am not defending those teachers who are advocating the adoption of communism or any other "ism." These self-styled intelligentsia are often more dogmatic and more dangerous than the unthinking and dogmatic conservative. I say more dangerous because, with an abrupt adoption of untested schemes there is the likelihood of upsetting natural balances to which civilization has become gradually adjusted, and this sudden change may lead to entirely unsuspected and violent disturbances.

On the other hand, I am defending those teachers who are trying to encourage their pupils to think for themselves, to examine controversial topics in the hope that better understanding may lead to improvement. Although there may be marked disagreement concerning what constitutes improvement or just where changes should be made, few, if any, will maintain that no improvement of any sort is possible in political, scientific, social, religious or economic practices. It follows of necessity therefore, especially in a democracy, that the citizens should have training in evaluating the evidence that is offered in support of, or in opposition to, proposals of various sorts. If, however, teachers by choice or coercion merely pass on accepted information, education becomes static and there can be no progress; and yet many of our citizens, including also by far too many teachers, consider that the major function of an education consists in forcing the pupils to accumulate a mass of information, or in indoctrinating them with certain beliefs.

Advances in the various fields of the sciences during the past one hundred years or less have profoundly affected our physical well-being, and have also had a marked influence on thought not only in science but in the fields of philosophy, religion, economics and social relations. Because of a recognition of these great achievements in the fields of science, increasing attention has been given to the teaching of sciences in our schools. Usually, however, the main emphasis, and often the only emphasis in the teaching of science, is placed on the presentation of a formidable array of facts and information which the pupil is supposed to store in his memory. But is this memorization of facts the most important function of an education in science? If not, what should a student get from his course in science?

He certainly should get some idea as to the method and view-point of science. By method I do not mean the details of technique but the broader principles.

He should become acquainted with the methods of discovering facts, of obtaining evidence, and he should have experience in critically evaluating this evidence.

He should have some training in what constitutes evidence, and learn to distinguish between what is, on the one hand, mere assumption, dogma or opinion based on prejudice or on fragmentary evidence that is open to several alternative explanations, and, on the other hand, knowledge based on verifiable proof that is not open to alternative interpretations. To the man who bases his conclusions on dogma handed down from generation to generation, it may seem a new and revolutionary idea when he comes to realize that totally independent investigators can arrive at the same truth, even though they use different methods and start perhaps with different premises. The student should appreciate that something is true, not because some great individual said so, but the man discovered it because it is true. Neither apostolic succession, a controlled

school system, nor an inspired press is necessary to carry on truth. On the contrary, these are likely to prevent progress, not promote it.

The student in science should learn to evaluate evidence and draw his own conclusions, and not merely accept an answer given by a book or a teacher. I am afraid we teachers too often discourage independent thinking. We expect correct answers or answers in the same words as we ourselves have formulated them, and pay too little attention to the type of reasoning which leads to the answer. Often a minor slip leads to an unsatisfactory answer when the main line of reasoning is the student's own and is perfectly sound. In attempting to get the answer satisfactory to the teacher, the student is often forced to learn by rote. He may then present a suitable answer but have no clear idea as to the underlying principles. I knew of a high-school teacher of geometry who forced her students to use the same lettering as the text in proving a theorem. If the letters were changed she could not prove it herself. She had learned by authority, had memorized the formula, and was passing it on verbatim. She did not herself understand the proof.

The student in science should learn to use the principles he has been studying in solving problems for himself. He should be encouraged to make frequent applications of these principles to every-day happenings. This will favor the transfer of training and make the training of greater value.

The student of science should appreciate the willingness and keen desire of the true scientist to reconsider his former conclusions; to look for evidence opposing his conclusions, not only for that supporting them, so that all weaknesses may be discovered and removed from the foundation of the structure he is building; to change his opinion if necessary; or to reserve his conclusion and suspend final judgment if the evidence seems inadequate or contradictory.

Is it not true that commonly the chief emphasis, if not the only emphasis in teaching science especially in the elementary courses, is devoted to the imparting of information, presenting the results of scientific investigations? Even in many of the more advanced courses and in the texts at all levels, the method of presentation in the text, the questions asked in the text and by the teachers deal largely with information and not interpretation. When interpretation is called for, the student is often asked merely to recall or recite the interpretation given in the text or by the teacher. It may be useful to know the answers to questions concerning simple definitions, the dates of specific happenings, the conclusions of specified individuals, the descriptive characteristics of various structures or substances, lists of the names of things, etc. A teacher can ask and correct answers to such questions without great mental exertion. Perhaps that is why so many teachers have settled into their little ruts and are satisfied with that type of testing and teaching. Answers to a high proportion of such questions usually merely involve memorization and recall. Some of the facts asked for may be useful or necessary, but many are of no real significance. It would seem better to set problems that involve an understanding of the principles and their applications, problems that involve a critical evaluation of the evidence bearing upon interpretations. To solve these problems they must not merely recall a few facts but must understand them and be able to use them in their thinking.

Instead of placing the major emphasis upon memorization of facts and information, therefore, would not our science teaching be much more meaningful if we emphasized these other phases that I have just mentioned? Do not the same points apply also, though perhaps with differing degrees of emphasis, in all teaching, whether it be science, history, literature, economics or religion?

As I have just said, one really interested in the truth should be constantly on the lookout for possible flaws in his conclusions or in the supporting evidence, and should actively search for possible opposing evidence to make sure that he has not overlooked something. Unfortunately most humans in their desire to prove themselves correct are prone to shut their eyes to opposing evidence or belittle it when it is brought to their attention. This undesirable trait finds many illustrations in most fields of education, and its fallacies and dangers should be stressed in our teaching. One might wish that this weakness would not appear in the field of science, but of course all scientists are human and show the same trait in varying degrees. It was not long ago that I learned of the following episode. One individual who was engaged in teaching and research in a given field of science had found several questionable statements in a publication of a second individual engaged in the same type of work. The first wrote to the other offering to send him a list of the points which he questioned. He was astonished to learn, however, that the writer of the article was not interested even in finding out what evidence or what interpretations were being questioned. How a scientist could be so sure of himself that he isn't interested in learning what mistakes another investigator working in the same field may think he has made, or what alternative interpretations he may have to offer, is beyond my comprehension.

One might think that the increased teaching of science subjects in our schools, and a recognition of the marvelous advances resulting from the use of the scientific method would have valuable educational effects, giving training in more independent and critical thinking and in avoiding superficiality, inexactness and sensationalism. But in much of our teaching, per-

haps especially in our science subjects, the teacher or text supplies a systematic array of so-called "facts" which the pupil is supposed to store in his memory. We are trying to make walking encyclopedias, not intelligent beings. Where laboratories are used, the student is given a chance to familiarize himself more thoroughly with these facts, and to fix them more definitely in his mind. They also give experimental proof of the fact, which is certainly better than trusting entirely to teacher or text, but at the same time the experiment proves that the teacher and text are right. Usually the simpler and more dependable experiments are selected for the student to repeat. They are therefore almost certain to come out right. If not, the student becomes discouraged. The expected results, however, are usually obvious, so if the student does not get them he often "fakes" them. Have the experiments therefore been as valuable as we thought?

A university professor in a science subject not long ago told me that most of his laboratory experiments were "fool proof." He said, "They are bound to come out right even if the student is careless." His course is highly systematized; students are well satisfied; things behave as expected. A high-school science teacher told me recently that most of his demonstration experiments were "faked." I know of another university professor who doesn't hesitate to "fake" demonstrations at science meetings or to slip into the laboratory after the students have gone and add products to their experimental flasks to make the experiments come out "right." But does this give training in science? Will this training help the student when he meets everyday problems and must make his own decisions? Does not this lead to over-confidence, to a false confidence and eventually to disillusionment and bitterness? No wonder students after they leave school become discouraged when their theories do not work. No wonder children as well as older people, who have been trained by authority and dogma, in the home, in schools and in church, become so severely upset, or revolt against all their early training—the true and false alike—when some of the so-called facts, so dogmatically taught them, are eventually found to be false or based on no foundation of evidence. What training have they had in distinguishing the true from the false; in meeting and solving problems for themselves?

Personally I prefer to set up experiments that will not come out as the student expects, and I am occasionally pleased if they come out "wrong." If the student knows the answer, why do the experiment? If it comes out as he expected, what has he learned? It is true that he may remember the point more easily and if it is highly important—well and good. He may learn something also of the techniques of experimental science. If, on the other hand, the results are not those expected, he has something to explain. If his original idea was correct he may not learn much by proving it. If it was wrong he must modify his idea. More often the expectation was correct, but there was some slip in the manipulation, or some complicating factor that was overlooked. If he finds what it is, he has learned something. In attempting to square his results with his expectations he will learn something of science and scientific method. If the experiment is "fool proof" or the data are "faked" the student gains nothing and may lose much. Of course if too many experiments come out "wrong" a student is likely to get discouraged and blame the teacher, the equipment, his partner or the subject.

As our knowledge of facts and laws of science increases, I am afraid it is becoming increasingly true that so-called "science" is being taught more and more dogmatically. In physics, for example, or in chemistry or in biology, there are so many laws and facts that are known and well established that it requires most of the available time of a course to present a survey of these facts, and little or no time is left for considering seemingly contradictory evidence, that is, for training in scientific methods and attitudes. It is true that in these days the texts are being constantly revised so that the information is more nearly up to date than formerly. But many teachers using such texts complain because of the necessity of change. I know of one teacher in a field of science who prefers to use a text written in 1896 to those written more recently. It is easier of course to learn once for all time and not have to change. Perhaps such teachers would prefer to have their own subject as static as medicine was between the second and sixteenth centuries. Galen's writings on anatomy and medicine, which were written in the second century, were used as authoritative texts for one thousand four hundred years. Galen and his writings were used not as an example, not as a step toward a better understanding, but as a final authority; instead of a new beginning in medical advancement it was the end of advancement for 1,400 years. An inflexible text or creed or formulation of a principle or hypothesis, if fixed in its details so as not to allow for growth or change, although useful and an improvement at the time of its formulation is likely to interfere with progress. Vesalius about 1543 questioned some of the statements ascribed to Galen and began to investigate for himself. His teachings and his studies were considered sacrilegious, and he was persecuted for them and narrowly escaped death at the hands of the Inquisition. One of the students of Vesalius said that his teacher not only demonstrated new truths to him, but "so taught that the student could discover new truths for himself," could develop beyond what he was taught. *Is not that the test of sound teaching?*

When new interpretations or conclusions are pre-

sented in our revised texts or revised lectures are the old ones displaced and the new merely substituted for the old? Would it not be much better occasionally to present some of the old conclusions with the supporting evidence, then give the new evidence showing why it was necessary to change our conclusions? Some students, however, resent having to decide for themselves, perhaps because from childhood they have been told what to believe.

I was developing contradictory evidence of this sort one time when a student, who was carefully taking notes, slammed his notebook with disgust, saying, "You tell us one theory and then contradict it." Another time I was giving contradictory evidence and pointed out how I was not sure myself which interpretation was correct. A student asked, "Why bother about these things when you do not know yourself?" "Why bother about outworn, discarded theories?" "Give us the things you do know about and let the rest go." Give answers; give the "latest dope." I pointed out, of course, that some texts and some teachers do give one side only as the truth, others the opposite side, and I hoped that, by considering both sides they would have a better understanding of the real truth. I well remember the case of a student who dropped a course in plant taxonomy because the professor said he could not tell for certain to which of two species a given plant belonged. It was intermediate and had characteristics of both species. This student "refused to study under a professor who did not know his subject." I have also heard of another professor in the same field of botany, a member of an organization in which much of the teaching is by authority. This professor, when he found such intermediate plants that could not be definitely classified, destroyed the plants, remarking that "they were the product of the devil."

To present only clearly established information, leaving out all the uncertainties, gives the students an entirely wrong view-point. It is not training him in science nor does it give him understanding. A professor in a department of horticulture at a well-known college of agriculture was greatly liked by his students. He was clear-cut and definite in his teachings, telling the students just what to do. Several years later some of his students reported that this course, which as students they had thought the "best" in their university course, was really the "worst." The rules did not work and they had no training in meeting problems. I think it was Mark Twain who said that after a long life full of many experiences he had found that it wasn't the things that he did not know that gave him most trouble, but the things he knew that weren't so.

Another case that came to my attention was that of a girl who had taken courses in a department of home economics where the latest findings were presented, but with no training in evaluating the evidence. When she returned to the university two or three years after graduating, she attended a lecture in which the conclusions were in direct contradiction to those of her previous training. She had been taught facts and conclusions and had not been trained to draw conclusions from evidence. She was greatly disturbed and at a loss to decide what to do. With such methods of teaching information only, one would need to return to school every few years to keep up with the information. Perhaps our college degrees should be labelled "good for five years only." Why not teach in such a way that the student can carry on, as did Vesalius and some, but too few, of our teachers to-day? Not long ago there was an article by Christian Gauss[2] which bore the title, "Why Don't College Graduates Stay Educated?" In my opinion the answer is that we have not really been educating them. We have been merely giving them conclusions, answers to specific questions, and have not been training them in evaluating evidence, in the methods of solving problems for themselves, in methods of continuing education.

I was speaking along this line before a small group a few years ago when one of the professors (one whom I admire and one who is, I think, a stimulating teacher for advanced students) remarked that, contrary to his usual custom, he was that year using a text. The text made statements which he knew were wrong. He hated to let them go unchallenged, but since he was teaching from the text he said nothing. But of what value is the teacher if he merely drills his pupils on information, false and true alike, which is already available in the text? This same professor said, "Surely you do not bring contradictory evidence into an elementary course?" I replied, "Of course, I welcome an opportunity to bring controversial material into an elementary course, especially if it is of such a nature that the student can easily appreciate the evidence." Then the student can get some feeling for the method of science, a truer idea of the real state of things, a truer understanding. If one attempts to present controversial material in an elementary course or text it is likely to make the course too long or the text too bulky, or it may necessitate the omission of important material. But, on the other hand, I sometimes wonder if we don't try to make our courses too complete and thereby lose depth. By depth I do not refer to more detail. Detail is often unnecessary padding.

If time is limited, why not leave out of the lectures or discussions much of the well-known material? Of course the student must have some basic information, but that is available in the text or reference books and original articles. What he needs from his teacher is

[2] *Saturday Evening Post*, 208: 26, December 7, 1938.

not more information, but where to find it when he needs it; and still more how to evaluate it, and how to use it. In some elementary courses it may be better to use the historical approach and show how at one time the available evidence supported a given conclusion, but how new evidence has led to the necessity of change. Then by definite comparison one can show how some of our present-day conclusions may need revision in the light of new evidence not now apparent. With many of our students, most of them in fact in colleges of arts and sciences, an elementary course or two is all they will ever get in science, so if they do not get a truer picture in this elementary course, where will they get it?

That many college-trained people have little or no appreciation of scientific principles is indicated by the frequent appearance in current monthly and weekly magazines and newspapers of supposedly serious articles purporting to deal with science, and yet the writers demonstrate abysmal ignorance of some of the most elementary scientific principles. This is partly due, I think, to poor teaching in our elementary science courses, especially that in the biological sciences, and in part to the fact that only a small proportion of the students who receive the A.B. degree from colleges of arts and sciences have had more than one or two freshman courses in some science. From a preliminary study that I have been making, it appears that a large number of those students taking their major work in English, foreign languages, history, philosophy and such have had less than 6 per cent. of their college work in the sciences, including both biological and physical sciences, while about 50 per cent. of these students have had no biological science whatever. Yet it is from this group that a large proportion of secondary school teachers, writers and journalists probably come. These writers and teachers perhaps shudder at mistakes in spelling or grammar, and we all enjoy the "howlers" in student papers in history, geography and such; but too few have had adequate training in the sciences to recognize the frequency of the ludicrous mistakes in these fields as they appear in writings in supposedly reputable magazines and newspapers. There is little difference between many college graduates and those who have not gone beyond the eighth grade in so far as their mental attitudes or judgments in the fields of science are concerned. Recent articles like "Chemistry Wrecks the Farm," "The Chemist Conquers Agriculture," "Civilization Faces a Joke," and a host of similar supposedly serious articles, merely demonstrate the vast ignorance of the field of biology of many writers, journalists and editors. Newspaper editors would hardly dream of sending a reporter who had never seen a football game to write up such a game for his paper, yet they expect reporters who have had no training whatever in science to write on the work of scientists.

It seems to be assumed by many writers and editors that the only things that will interest the general public in science is the spectacular, the miraculous, the colossal or the seemingly impossible at last come true. Of course it is more difficult to make clear and interesting the more critical aspects of science and the scientific method, but opportunities for doing so are not utilized. That many people are interested in following the development of seemingly contradictory evidence and the unfolding of hidden clues is indicated by the wide-spread interest in detective stories. One wonders whether a similar interest in science might not be awakened.

The public is becoming so accustomed to startling and even revolutionary discoveries in the fields of science, to such sudden apparent shifts in conclusions, that there seems to be developing a rather dangerous attitude among certain people. It is true that some individuals are over-conservative, over-prone to decide once for all on a subject and never reopen it for new light. But others go to the opposite extreme, become so accustomed to change that they have no convictions, no basic theories of life; are so afraid of being considered behind the times that they go to the other extreme and blindly follow every new fad. This "open-mindedness," as they perhaps call it, might better be described as "empty-mindedness." Our public school system ought to combat this tendency and not foster it. The sophisticated and disillusioned youth who has no convictions and becomes skeptical of all things may have been forced into such an attitude because he has been dogmatically taught one contradiction after another, and has been given no solid foundation training for forming his own judgments. But here again, is it not the emphasis on the findings of scientific investigations, findings that have led to frequent changes in practices, which have given the appearance of insecurity? Is it not the failure to emphasize the method and attitude of science that is at fault? The emphasis has been put in the wrong place, on the seemingly miraculous result rather than on the rigorous discipline that led to the new discovery. Truth and the underlying methods of discovering truth do not change.

The public has become so accustomed to the seemingly miraculous accomplishments in the fields of science that instead of using the scientific method and examining evidence critically, building on a solid foundation, many people merely become more gullible and accept any claim, no matter how fantastic. You will all recall the recent excitement over the supposed invasion from Mars. The astonishing developments in the field of the radio seem on the surface highly miraculous and, to many who have no understanding of the under-

lying physical principles, it seems but a simple step to telepathy, and from that to communication with the spirits of the dead. I have heard college-trained people cite the radio as proof for spiritism. It may be amusing at times to let one's imagination run riot, and sometimes giving free rein to unchecked imagination, fanciful thinking or appeal to superstition may have no dangerous outcome. But, for example, if the faith healers could gain complete control over medical and sanitary procedures and practices, the unchecked plagues of smallpox, typhus, cholera, yellow fever, typhoid and such would decimate a large part of the population of the world, and what are now only isolated tragedies resulting from the failure of misguided and ignorant individuals to make use of proven remedies would become devastating conflagrations.

Is there not something wrong with our educational systems when in this so-called scientific age we find, among our high-school, college and university graduates, many who believe nothing definite and have no convictions, while many others will believe anything, no matter how fantastic? Is there not something wrong when so many join the ranks of the fundamentalists, fighting the teaching of truth about evolution and progress as it applies to biology? When so many others join the ranks of the "one hundred percenters" opposing the recognition of truth in history, in economics, or in government? When many are so gullible as to be deceived by the most faulty and superficial reasoning? Has not the teaching of science failed when so many taking these high-school and university courses join the ranks of the faith healers fighting sanitation and health measures, degrading both religion and science? It is clear that some of the most elementary principles of science are disregarded by those graduates of our best universities who go to fortune tellers and astrologers for advice, or for spirit messages from the dead; who feel uncomfortable unless they knock on wood; are superstitious about so many things, about lucky or unlucky numbers, about black cats or walking under ladders; who rely on charms or "lucky" pieces of one sort or another, or who forward chain letters for fear of bad luck.

When we recognize these weaknesses of those who are the products of our institutions of higher learning, weaknesses typical of primitive peoples or those with but few educational opportunities, we must recognize that part of it must be due to weaknesses in our educational system and methods. Part, I am convinced, is due to the fact that large numbers of students, as well as teachers, have had little or no training in science, especially in those phases of the biological sciences that bear upon one's everyday thinking and behavior. Part, I feel, is certainly due to the emphasis on teaching *what* to think rather than *how* to think; to a tendency to teach by authority, by dogma, rather than for authority, for understanding.

One of the more telling points in an article by Dallas Lore Sharp on "Education for Authority"[3] was his free translation of the Biblical passages as follows: "The people were astonished for He taught them as one having authority and not as those who had gone to college." Is not too much of our teaching to-day like that of the scribes of old, too much like that of the followers of Galen, a mere passing on of information, with little or no training in understanding? Are we not failing in helping our students to gain a real understanding, to gain an attitude of mind which aids in solving problems, in the discovery, unfolding and appreciation of truth and a recognition of values? Are we building a foundation that will lead to further growth and to a more satisfactory living?

As I look at it, science is successfully taught only as its teachers can get their pupils to appreciate how advancement in knowledge is accomplished only gradually and by the critical examination and reexamination, the testing and retesting, of each step in a fabric of evidence; and how the truth is clarified only after the many possible weaknesses or alternative interpretations are critically examined and tested from all angles and by many workers. Training in science should make the individual more critical, not more credulous, should lead him out of superstition and not sink him deeper into the attitudes of the superstitious.

I have been contrasting methods of teaching science, that is, teaching by drilling the students to memorize the conclusions of others, a mere accumulation of information, as contrasted with training in evaluating evidence, in understanding and in solving problems for themselves. Is not a training for real understanding, for authority, immensely superior to teaching by authority or by dictation? Do not the principles apply to all ages from the first grades in school to old age? Do not the same principles apply also to each of us as individuals, not as teachers, but as students continuing our education? Are we as individuals meeting problems by attempting to understand them or are we accepting authority, either from our former or present teachers or from our own past conclusions which perhaps were based on incomplete evidence? Are we as individuals growing, or are we static? In all fields of education, whether it be art or music, literature, religion, sociology, history, government, economics or one of the sciences, we need education for appreciation not by dictation, for understanding not by indoctrination, for authority not by authority.

[3] *Atlantic Monthly*, 128: 13–21, 1921.

SCIENTIFIC EVENTS

FUTURE OF THE SCIENCE MUSEUM, LONDON

THE future of the Science Museum, South Kensington, is discussed in the report of the Advisory Council and summarized in the London *Times*. It is recalled that in the report last year the council gave a brief résumé of its recommendations for the future of the museum as an integral part of a general project for the development of the South Kensington site. They afterwards issued a full report, and subsequently Lord Stanhope, then president of the Board of Education, received a deputation of the council.

Lord Stanhope, the present report states, expressed his sympathy and agreement with the council's recommendations as to the floor space needed for exhibition galleries, library and ancillary accommodation. "He expressed his doubts, however, as to whether the site area . . . would be available in its entirety without jeopardizing the whole project, and suggested that it might be necessary to confine the museum to a smaller site and erect a loftier building with exhibition galleries on four more floors."

The Advisory Council have expressed their "profound concern" at such a policy. "They understand that the site area which they require for the Science Museum only affects the project to the extent of precluding the location of another new museum on this already crowded site, and that the project is based on a tentative plan prepared early in 1937 before the needs of certain institutions were known.

"They reaffirm their opinion that it is unwise to erect a museum with several stories of exhibition galleries. Two, or at the most three, such stories should be the maximum, for the public are averse voluntarily to mounting higher, and upper galleries remain unvisited mausoleums. The modern practice in museum buildings in other countries confirms our opinion."

The council considers that the site area they request for the Science Museum in the future falls short of the areas now occupied by the other major national museums. While maintaining its function of preserving historical records of science and industry, it should be in a position to serve a wider educational purpose in connection with the national industries.

EXPEDITIONS OF THE FIELD MUSEUM, CHICAGO

THE paleontological expedition of the Field Museum of Natural History, under the leadership of Assistant Curator Bryan Patterson, has begun operations in western Colorado. Mr. Patterson is accompanied by James H. Quinn, also of the department of geology, and a corps of volunteer workers will be recruited in the vicinity of the excavations.

The expedition will remain in the field for about three and a half months. The field of operations lies in Mesa, Garfield and Gunnison Counties, where an extensive series of formations belonging to various periods and eras in the earth's history is exposed. Important collections of fossil animals and notable additions to knowledge have already resulted from previous expeditions conducted in this general region during 1932, 1933 and 1937. This program will be continued by the present party, which will carry on work mainly in late Paleocene and early Eocene deposits (the opening epochs of the Age of Mammals), with some attention also being paid to the late Cretaceous formations (the closing period of the Age of Reptiles).

The main objective of the expedition is to collect fossil mammals from the Paleocene and Eocene. Specimens from these early horizons are of great interest to students of mammalian evolution. The dinosaurs and other reptiles that had previously dominated the earth were but a short time extinct (geologically speaking), and the mammals were just getting well under way. Many groups that no longer survive were flourishing, and several of the dominant mammalian types of the present time were represented by exceedingly primitive ancestors.

In addition to the work on vertebrates, attention will be paid to geological observations and to the collecting of fossil plants. It is hoped that by means of the latter it will be possible to make somewhat more precise age determinations and correlations of the late Cretaceous formations than has hitherto been done.

The expedition which has been collecting marine animals and other invertebrates along the Atlantic and Gulf coasts of Florida since early in May has completed its work. Dr. Fritz Haas, curator of lower invertebrates, and Staff Taxidermist Leon L. Walters, who conducted the expedition, have returned to the museum. More than 6,000 specimens, representing the most important features of the invertebrate life forms native to the region, were collected. On Sanibel Island, Dr. Haas conducted researches on the relationships between the various types of fauna and the environmental conditions in which they are found. He also investigated the rôle of molluscan life in building up land through the accumulation of shells.

One of the main objectives of the expedition was the collecting of material and data for a proposed habitat exhibit of the loggerhead turtle. This material was collected on Sanibel Island, and plaster molds were made which will form the basis for life-like reproductions. Mr. Walters was fortunate in being able to observe the entire nesting procedure.

THE LEVERHULME RESEARCH FELLOWSHIPS

THE Advisory Committee for the Leverhulme Research Fellowships has recommended, and the trustees have approved, the following awards, tenable for varying periods up to two years:

W. H. B. Court, M.A., lecturer in economic history, University of Birmingham, "India and British Economic Policy in the Past Century."

W. Cule Davies, D.Sc., Ph.D., lecturer in chemistry, University College, Cardiff, Leverhulme Research Fellow, "Studies of the Organic Compounds of Nitrogen, Phosphorus and Arsenic."

R. M. Davies, D.Sc., lecturer in physics, University College, Aberystwyth, "Experimental Investigations on Turbulent Flow in an Air-tunnel."

R. Dennell, M.Sc., assistant lecturer in zoology, Imperial College of Science and Technology, London, "The Structure and Physiology of the Luminous Organs of Atlantic Deep-sea Crustacea."

R. W. Firth, M.A., Ph.D., reader in anthropology, University of London, "The Social Structure and Economic Organization of Rural Malays."

D. Ll. Griffiths, F.R.C.S., clinical assistant, Orthopedic Department, Manchester Royal Infirmary, "The Comparison of Radiological and Histological Features in Bone Tumors."

A. E. Ingham, M.A., university lecturer in mathematics, Cambridge, "The Analytical Theory of Numbers."

B. Jones, B.Sc., Ph.D., lecturer in chemistry, University of Sheffield, "A Study of Reaction Kinetics in Solution."

E. B. Maxted, D.Sc., Ph.D., special lecturer in catalysis, University of Bristol, "Studies in Catalyst Poisoning."

D. A. O'Duffy, B.Sc., research and development assistant, Bahrein Petroleum Company, Leverhulme Research Fellow, "Lubrication Problems at High Temperatures and Pressures.

L. F. Taylor, M.A., I.E.S. (Ret.), late research lecturer in Indo-Chinese ethnography and linguistics, University College, Rangoon, "An Ethnographical and Linguistic Survey of Burma."

Miss M. L. Tildesley, chairman of the Comité de Standardisation de la Technique authropologique, London, "The Definition, Measurements and Classification of Anthropometric Characters."

W. A. Waters, M.A., Ph.D., lecturer in chemistry, University of Durham, "Mechanisms of Reactions Involving Free Organic Radicals."

E. L. E. Wheatcroft, M.A., professor of electrical engineering, University of Leeds, "The Mechanism of Development of Electric Sparks with Reference to Lighting Discharges."

THE SEVENTEENTH CHEMICAL EXPOSITION

THE seventeenth Chemical Exposition will be held in the Grand Central Palace, New York City, during the week beginning on December 4, when it will celebrate the completion of its twenty-fifth year of service to the chemical and allied industries. Many of the exhibitors in the first exposition, which was held in 1915, have engaged space this year. It is now established on a biennial basis.

Three floors of the Grand Central Palace have been reserved for the exposition, which will include chemicals and chemical products, laboratory equipment and supplies, instruments of precision, materials handling equipment, brewing, distilling and bottling equipment, industrial chemical machinery and materials, containers and packaging machinery and materials of construction. At the last exposition more than 46,000 visitors attended, representing 45 states in the United States and 130 cities and towns in 47 foreign countries. Members of the Advisory Committee include the presidents of the principal chemical organizations. Its chairman is Dr. M. C. Whitaker, long a leading figure in the chemical industry. Charles F. Roth, who has been similarly responsible for the preceding expositions, will be personally in charge.

The student course in chemical engineering which has become an established feature of the exposition, will again be presented. Professor W. T. Read, dean of chemistry of Rutgers University, who has served as director in previous expositions, will this year again be in full charge. This course enables the selected college students who enroll to coordinate lectures by leading authorities with actual examination of the materials and chemical engineering equipment discussed.

Unit processes of chemical engineering will be represented by a broad range of exhibits. Combustion processes include furnaces, kilns, refractories and the recording instruments essential for regulation and control. Crushing, grinding and mechanical separation will be represented by sifters, agitators, classifiers and ball mills. Classification of materials based on magnetic properties also will be demonstrated. Advances in the processes of filtration, evaporation and drying will be illustrated by many exhibits. Apparatus will include filters of every type and evaporating equipment applicable not only to the chemical industries but also to the food industries. Drying equipment will be shown in its relation to every phase of the pharmaceutical industry, and there will be special reference to the processing of foods.

EXHIBITION OF THE AMATEUR ASTRONOMERS ASSOCIATION OF NEW YORK CITY

THE first national exhibition of the work of amateur astronomers was opened in the American Museum of Natural History on July 30 and will close on August 20. The exhibition is sponsored by the Amateur Astronomers Association of New York City and by other societies in the metropolitan area. It includes exhibits from more than two hundred amateur

astronomers belonging to more than thirty clubs throughout the country.

A national convention of amateur astronomers, with sessions at the museum and the New York World's Fair, will be held on August 19 and 20, the closing days of the exhibition. August 19 will be Amateur Astronomers Association Day at the New York World's Fair. An address "Astronomy in the World of To-morrow" will be given on that day at the fair by Dr. Harlow Shapley, director of Harvard College Observatory.

A nine-inch reflecting telescope made by school students in Flint, Mich.; star photographs from an amateur in New Brunswick, Canada; lens-making tools from Lewiston, Maine, and a home-made spectroscope from Norwalk, Conn., are among the exhibits. The Alabama Astronomical Association shows photographs; Earl C. Witherspoon, of Sumter, S. C., is displaying a home-made Herschel wedge for use in solar telescopic observations. A Schmidt camera, the new type of telescope now being widely used by professional astronomers, difficult of design and construction, is being exhibited by Stanley Brower, of Plainfield, N. J., with samples of stellar photographs. A celestial globe, complete with automatic electric motions, is being shown by E. C. Stanton, of Bethesda, Md. The Cook Observatory of Wynnewood, Pa., is exhibiting photographs of its equipment and samples of its work. Exhibits from members of the National Capital Amateur Astronomers Association in Washington, D. C., are also on view. The New Haven Astronomical Society includes in its exhibit tools and devices used in the production of telescope mirrors, grinding machines, testing apparatus and the like. Donald S. Kimball, president of the group, is showing a series of forty-four auroral photographs taken from his home in Hamden, Conn.

Visitors are invited also to visit the workshop of the optical division of the association in the basement of the Hayden Planetarium, where they may watch the making of telescopes, mirrors, lenses, mountings and other equipment. The Junior Astronomy Club is represented by photographs and the paintings made on its 1932 eclipse expedition to Peru, as well as by instruments constructed by its members.

Honorary life membership in the association will be presented during the convention to Leslie C. Peltier, of Delphos, Ohio, who has to his credit the discovery of several comets and novae. A special performance will be given at the Hayden Planetarium and at "Time and Space," the special exhibit of the museum at the World's Fair. The exhibition will be open on week days and Saturdays from 10 A.M. to 5 P.M. and on Sundays from 1 P.M. to 5 P.M.

RECENT DEATHS AND MEMORIALS

DR. WILLIAM JAMES MAYO, of the Mayo Foundation and the University of Minnesota, surgeon and chief of staff of the Mayo Clinic, died on July 28 at the age of seventy-eight years.

DR. WILLIAM ARTHUR TARR, professor of mineralogy and geology at the University of Missouri, died on July 28. He was fifty-eight years old.

DR. HARTLEY BURR ALEXANDER, professor of philosophy at Scripps College, Claremont, Calif., previously professor of philosophy at the University of Nebraska, died on July 27 at the age of sixty-six years. In addition to his publications in philosophy and psychology Dr. Alexander is known for his work in Indian anthropology.

DR. ALFRED HARKER, emeritus reader in petrology at the University of Cambridge, a fellow of St. John's College, died on July 29 at the age of eighty years.

Nature announces the death of Dr. W. A. Jolly, professor of physiology in the University of Cape Town, and of Brigadier-General the Hon. C. G. Bruce, leader of the Mount Everest Expeditions of 1922 and 1924.

As a permanent recognition of the contribution of the late Professor Charles Sumner Plumb, the animal husbandry building of the Ohio State University will be called "Plumb Hall," on the recommendation of the College of Agriculture, in which Professor Plumb served as professor of animal husbandry for thirty-seven years. At the same time the board of trustees recorded its "profound appreciation and the gratitude of the university for the gift of the priceless library" of Professor Plumb, whose death occurred in March. The library consists of more than 1,600 items.

SCIENTIFIC NOTES AND NEWS

THE "golden jubilee" of David Fairchild, formerly chief of the Division of Plant Exploration and Introduction of the U. S. Department of Agriculture, author of "The World is My Garden," who joined the department fifty years ago, was marked on July 24 at Glenn Dale, Md., when Secretary Henry A. Wallace presented him with the Frank N. Meyer Medal. This was the sixteenth award of the medal, which was established by the will of Mr. Meyer, who was also a plant explorer of the Department of Agriculture.

THE Southern Minnesota Medical Association has presented its annual gold medal to Dr. Vernon L. Hart, professor of surgery at the medical school of the University of Minnesota, for the best scientific exhibit at the recent meeting of the Minnesota State Medical

Association. Dr. Hart's subject was "Fracture Problems."

THE senate of the University of Glasgow announces the award of the Struthers Gold Medal and Prize to Dr. George M. Wyburn for a series of embryological studies embodied in papers published in the *Journal of Anatomy*. The Harry Stewart Hutchison Prize has been awarded to James Holmes Hutchison for his dissertation entitled "The Iron-deficiency Anemia of Childhood."

IT is stated in *Nature* that Dr. Emil Abderhalden, professor of physiology at Halle, and Dr. Max Planck, professor of theoretical physics at Berlin, have been elected honorary members of the Société Philomathique of Paris.

THE University of Leeds has conferred the degree of doctor of science on Dr. W. L. Bragg, Cavendish professor of physics at the University of Cambridge.

THE University of Tasmania has conferred the degree of doctor of science on John William Evans, government entomologist of the Department of Agriculture, Tasmania.

DR. MARJORIE S. HARRIS, professor of philosophy at the Randolph-Macon Woman's College, Lynchburg, Va., has been elected president of the Southern Society for Philosophy and Psychology; Dr. Norman L. Munn, professor of psychology, Vanderbilt University, has been elected secretary and treasurer.

DR. FRANK BRAWLEY, of Chicago, has been made president-elect of the American Academy of Ophthalmology and Otolaryngology. He succeeds Dr. Albert C. Snell, of Rochester, N. Y., who has resigned because of ill health.

THE following members of the faculty of the Ohio State University are among those who will retire with the title professor emeritus on September 1: Dr. Clair A. Dye, dean of the College of Pharmacy, who has been on the faculty for forty-nine years; Charles W. Foulk, professor of chemistry, and Christopher E. Sherman, professor of civil engineering, for forty-three years; Frank C. Caldwell, professor of electrical engineering, for forty-six years; Horace Judd, professor of mechanical engineering, for thirty-seven years, and Elmer G. Horton, professor of medicine, for thirty-seven years.

DR. BIENVENIDO M. GONZALEZ, from 1927 to 1939 dean of the College of Agriculture, has been elected president of the University of the Philippines. Dr. Leopoldo B. Uichanco, professor of entomology and head of the department of entomology, will take his place as dean of the College of Agriculture.

ADELBERT DIEFENDORF, for the last nine years professor of civil engineering at the University of Pittsburgh, has been made head of the department of civil engineering at the University of Utah.

DR. R. D. HAWORTH has been appointed to the chair of chemistry in the University of Sheffield in succession to Professor R. P. Linstead, who has resigned. Dr. Wilson Smith has been appointed professor of bacteriology in succession to the late Professor J. W. Edington.

B. L. GOODLET, professor of electrical engineering in the University of Cape Town, Union of South Africa, has been appointed to the chair of electrical engineering at the University of Birmingham to succeed the late Professor W. Cramp.

DR. K. N. KAUL, of the University of Lucknow, has become a member of the staff of the Royal Botanic Gardens, Kew, England.

PROFESSOR FRANCIS COLIN MINETT, director of the Research Institute in Animal Pathology at the Royal Veterinary College, London, and professor of pathology at that college, has been appointed director of the Imperial Veterinary Research Institute of the Government of India. He will leave for India late in August.

DR. DAVID F. SMITH, professor of chemistry at the University of Buffalo, has been placed at the head of the work on agricultural motor fuels at the Northern Regional Research Laboratory of the U. S. Department of Agriculture at Peoria, Ill. He plans to study methods of producing gaseous, liquid and solid motor fuels from agricultural materials.

BY action of the house of delegates at the annual meeting of the Ohio State Medical Association, a bureau of public education has been established in the executive offices of the association in Columbus. Richard A. Aszling, recently a member of the staff of the Dayton *Daily News*, has been appointed director of the bureau.

DR. VERN O. KNUDSEN, professor of physics and dean of the graduate division of the University of California at Los Angeles, has been named a member of the Los Angeles Building Commission. Dr. Knudsen has specialized in acoustical problems and in 1935 won the $1,000 prize of the American Association for the Advancement of Science for his research on the absorption of sound by gases.

DR. HARRY F. OLSON, director of acoustical research for the Radio Corporation of America, will inaugurate work in electrical acoustics at Columbia University. A study will be made of the possibility of improvement in the quality of sound reproduction in radios and motion pictures. The course is part of a program undertaken by the School of Engineering to enable practicing engineers of the metropolitan area to enroll for specialized academic studies. It is parallel with,

and complements, two other courses in sound production, one on communication electronics given by Dr. Eugene Peterson, of the Bell Telephone Laboratories, and the other on the acoustical properties of rooms and buildings conducted by Dr. V. A. Schlenker, of the department of physics.

HERBERT HOOVER has been named a member of a committee of the board of trustees of Stanford University to recommend a successor to President Ray Lyman Wilbur, who will retire on January 1, 1942. The trustees' committee will cooperate in the selection with an advisory committee of the Stanford Academic Council, composed of Dr. Eliot Blackwelder, professor of geology; Edwin A. Cottrell, professor of political science; J. P. Mitchell, registrar; Dr. C. V. Taylor, dean of the School of Biology, and Dr. Lewis M. Terman, professor of psychology. Dr. Wilbur's term was recently extended by the board of trustees beyond the retirement age of sixty-five in order that he might be president of the university when it celebrates its fiftieth anniversary.

HENRY LUNZ, in charge of the Seed and Weed Control Section of the Wisconsin State Department of Agriculture, was elected chairman of the Seed and Weed Council at a recent joint meeting with the Wisconsin Seed Dealers Association at Madison. He succeeds O. S. Aamodt, chairman of the department of agronomy at the College of Agriculture. The council is an organization of groups in Wisconsin interested in seed and weed problems, including the Wisconsin Experiment Association, the State Department of Agriculture, Wisconsin Seed Dealers Association, State University College of Agriculture, State Extension Workers Association, the Central Retail Feed Dealers, Wisconsin Bankers Association, Wisconsin Crop Reporting Service, the Association of Agricultural Instructors, the Wisconsin Council of Agriculture, and others.

ACCORDING to *The Australian Journal of Science* elections representing the States and the Australian Capital Territory on the Executive Committee of the Australian National Research Council have been made as follows: Australian Capital Territory: Dr. B. T. Dickson, Dr. W. G. Woolnough; New South Wales: Professor R. D. Watt, Professor W. J. Dakin; Victoria: Professor E. W. Skeats, Mr. W. E. Wainwright; South Australia: Sir Douglas Mawson, Sir William Mitchell; Queensland: Professor H. C. Richards, Dr. D. A. Herbert; Western Australia: Professor E. de C. Clarke, Dr. G. L. Sutton. Professor R. D. Watt has been elected deputy chairman.

DELEGATES to represent the United States at the seventh International Congress of Genetics at Edinburgh from August 23 to 30 have been appointed as follows: Dr. Hugh C. McPhee, of the U. S. Department of Agriculture, *chairman;* Dr. Albert F. Blakeslee, of the Carnegie Institution, Cold Spring Harbor, N. Y.; Dr. Lewis J. Stadler, of the University of Missouri, and Dr. Sewall Wright, of the University of Chicago.

PROFESSOR E. C. SLIPHER, of the Lowell Observatory, is visiting the South African Observatory of the University of Michigan at Bloemfontein in the Orange Free State for special observations of the planet Mars.

DR. N. H. DARTON is spending the summer in central Europe. He plans to visit Berlin, where he will read the proofs of his contributions to the American volume on the "Geology of the Earth," now in press in Berlin.

A PUBLIC meeting of the Chicago branch of the American Association of Scientific Workers held on July 18 at the University of Chicago was addressed by J. D. Bernal, professor of physics at the University of London, who spoke on the subject of his recent book, "The Social Function of Science."

THE American Astronomical Society will hold its sixty-second meeting at the University of California at Berkeley on August 7, 8 and 9.

THE twenty-fourth annual meeting of the Optical Society of America will be held at the Lake Placid Club, Essex County, New York, on October 12, 13 and 14. In addition to the usual program of contributed papers, a special program of invited papers is being arranged on the general topic of the "Optics of Vision." Papers are being prepared on the following subjects: Comparison of Structures of the Eyes of Humans and of Other Animals, Neural Connections between the Retinas and the Brain and Binocular Vision; Chemistry of Visual Systems, Recent Researches in Color Vision, Aniseikonia, Luminosity Methods and Results, Vision and Highway Accidents, the Supra-Threshold Realm of Seeing. The program committee is attempting to leave afternons free for recreation, except as this time may be required for committee meetings and similar activities. The annual dinner will be held on Friday evening, October 13, when the award of the Frederic Ives Medal will be made.

THE sixteenth annual meeting of the History of Science Society will be held in conjunction with the American Association for the Advancement of Science at Columbus, Ohio, from December 27, 1939, to January 2, 1940. The headquarters of the society will be at the Chittenden Hotel. Members wishing to appear on the program should communicate with Professor Louis C. Karpinski, department of mathematics, University of Michigan, Ann Arbor, Michigan. Dr.

Henry R. Viets, 8 The Fenway, Boston, Mass., is secretary of the society.

THE regular summer meeting of the Pennsylvania Academy of Science will be held at Laporte, Pa., on August 11 and 12. Field trips in botany and geology are planned. For further information, address the Secretary, Dr. V. Earl Light, Lebanon Valley College, Annville, Pa.

THE American Institute of Physics, New York City, has announced that it will conduct from November 2 to 4 a symposium on temperature. It is planned to coordinate the treatment of the subject of temperature in the several branches of science and engineering, to review principles and record recent work, to accumulate contributions for a comprehensive text to be published after the symposium, to emphasize the importance of temperature as a branch of physics and to improve technical curricula through making available up-to-date information.

DISCUSSION

SURFACE CURRENTS IN DEEP TIDAL WATERS

IN a recent article in SCIENCE, Shepard, Revelle and Dietz[1] report the discovery of unexpectedly strong bottom currents well out on the rugged continental shelf off the coast of Southern California. They note that these currents can not be explained as tidal currents of the regularly alternating type usually recognized, but must be due primarily to large eddies having no direct relation to the state of the tide.

Since some observations of my own during several summer vacations have led me to a similar conclusion about many surface currents in the deep water of the Inside Passage along the coast of British Columbia and since the importance of such eddies is only beginning to be recognized, I venture to present the results of these observations, even though they are only those of an amateur.

So far as I have observed, the times and heights of high and low water in the Inside Passage and its tributaries follow the predictions in the tide tables remarkably well, indeed so accurately that I have sometimes set my watch by them and later found it right within five minutes. The same is true of the times of turning of the current in the tidal rapids, of which there are at least ten on this coast strong enough to make white water. On the other hand, there are passages such as Welcome Pass, about 40 miles NW of Vancouver, where I have observed the current many times, and where there is no way to predict it at all. Thus on consecutive days with but little difference in the heights of the highs and lows, one may observe the current at corresponding tidal intervals and find it running in opposite directions on the two days, often with a strength of one or two knots, which is about as strong as the current gets in this pass. This pass differs from ones where the current can be predicted, however, in running parallel to a much wider alternative passage between the two bodies of water which it connects and in having only a moderately strong current.

[1] F. P. Shepard, R. Revelle and R. S. Dietz, SCIENCE, 89: 488, May 26, 1939.

Similarly along the shores of the Strait of Georgia, in the calm, clear weather that justifies the local steamship company in calling it "The Sunshine Belt," one may often observe currents of a knot or so, either alongshore or toward the shore or boiling up out of the bottom near the shore or meeting one another and sinking along a line made visible from afar by a thick accumulation of driftwood. Such currents all show a similar unpredictability.

My guess on the origin of these currents has been that they are eddies broken off from the strong tidal currents entering the Strait of Georgia through the relatively narrow Rosario and Haro Straits and Discovery Passage. With the configuration of the shore and bottom as it is, any such eddy, formed in the flood, can easily become detached from the current of the narrow strait and wander about aimlessly all over the Strait of Georgia. The observation of these unpredictable currents at places 60 or 80 miles away indicates that the eddies may persist for many days after detachment.

A similar effect occurs in the narrow fjords, such, for example, as Jervis Inlet. In this inlet the chart reports tidal currents of one knot, both ebb and flood, in places where calculations from the cross-sections of the fjord and the areas inland of those places would not indicate as much as one tenth of a knot, and where there are no big currents of fresh water like that of the St. Lawrence River. In some of those places at least, the currents are unpredictable. This I have observed especially in Jervis Inlet; and likewise in Alaska, in Le Conte Inlet. In the latter fjord I have observed the eddies only once, but that time with considerable detail owing to the fact that the eddies unexpectedly packed the small icebergs from Le Conte Glacier in around me and almost crushed my boat. On that occasion, with the boat unable to make her usual speed, the slow milling around of the icebergs gave a clear picture of the big, slow eddies.

My general conclusion from these observations, then, is that in deep waters of this type, aside from narrows or straits carrying exceptionally strong currents, the current at any point is most likely to be primarily

due to eddies having their origin in stronger and more strictly tidal currents at other places.

In this respect the deep waters of British Columbia and Alaska show a marked contrast to such shoal waters as Nantucket Sound, Massachusetts, where the currents are almost entirely strictly tidal. As a physicist I feel sure that the difference is due primarily to the great influence of viscosity in the shoal waters and the lack of it in the deep. In the same capacity, I would guess that there would be still less influence of viscosity in such larger and deeper waters as Shepard, Revelle and Dietz have been studying. Therefore we may expect their conclusions to apply very generally in deep waters with rugged bottoms.

DAVID L. WEBSTER

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PROBLEMS OF WOUND HEALING IN RED CLOVER STEMS

FORAGE legumes, like other herbaceous plants having no protective covering other than an epidermis, are subjected to injury by grazing animals and insects. In particular, the mowing of fields is a severe test both because of the wounds and also through the loss of the plant body including most of the buds. In spite of such injuries these plants are usually able to continue growth though frequently with some modification of form and size.

The stems of three important herbaceous legumes—*Trifolium repens* L., white clover, *Medicago sativa* L., alfalfa, and *Trifolium pratense* L., red clover—were studied with respect to the time and the nature of their wound responses. While primary interest centered in the healing processes, attention was given to various conditions, interrelated with lesion, which may cause the death of these legumes.

In connection with the healing of wounded herbaceous stems considerable credit must be given to the preliminary barrier or pseudocicatrice,[1] formed by death and collapse of tissue following injury. This, in itself, is protective in considerable degree and by checking the dying back of tissues permits certain underlying cells to develop a permanent barrier of wound cork, the cicatrice, which effectively heals the wound. Ultimately, in the three legumes studied, a region of solid living pith at some point in the injured stem permits the protective structures to be formed.

The pith in white clover generally remains alive and completely fills the central zone. Following a transverse cut a continuous pseudocicatrice quickly covers the injured surface. Suberin is demonstrable in the walls of the outermost living cells underneath the pseudocicatrice within thirty-six to forty-eight hours after lesion. By the sixth day suberization has extended from two to four cells further into the underlying tissues. About this time mitoses begin in subjacent cells, and this phellogen forms two to five additional layers of cork, which completes the cicatrice. Its development requires about fifteen days, and in final form it extends entirely across the stem, interrupted only by the vascular tissue.

However, in certain stems of white clover the central region of the pith dies and spaces develop. Following a cut across one of these hollow stems the pseudocicatrice can not be completed across the pith region, and water loss by way of this cavity causes the stem to die back to the nearest node. There a block of living parenchyma furnishes a foundation upon which a continuous pseudocicatrice is built. Four to five days may be required for the stem tissues to die back to this node, and both initiation and completion of the barriers are correspondingly delayed. Ultimately a cicatrice is always developed in the firm tissue of the node, similar to that which is built at the plane of injury in stems having solid living pith.

The pith of alfalfa stems is dead and broken throughout all internodes, but at the nodes there is usually a continuous living tissue. Consequently its healing processes correspond closely with those of white clover stems having dead pith. Dying back to the node takes five to ten days, but in the nodal zone the cicatrice is quickly formed. In general, mature alfalfa stems are safely healed within twenty-one days.

In red clover the pith is larger and makes up over half of the stem's diameter, relatively more than in white clover or alfalfa. Because this pith normally dies within two cm of the meristem, growth of the internodes breaks down the central tissue, leaving hollow stems. The nearest lower zone of solid living cells is at the junction with the crown, unless there is a growing lateral branch with sufficient living pith at the junction to permit the formation of protective barriers. The defective pith causes the whole axis to die downward to where a platform of living cells makes possible the establishment of the pseudocicatrice, which is quickly followed by the cicatrice of wound cork.

Due to this prolonged dying back of all wounded red clover stems there is necessarily a considerable delay in healing processes. When cut as low as four inches from the base there is a lapse of two to three weeks, even in midsummer, between the time of injury and the earliest evidence of healing. This means an interval of at least a month between the date of injury and completion of the cicatrice. This dying back of stems slows down later in the growing season and during the autumn months the development of healing tissues is greatly retarded or entirely inhibited. Rarely does a cicatrice reach completion before winter if a stem is cut across after early September. Successful healing takes place in the autumn only when

[1] Robert B. Wylie, *Bot. Gaz.*, 90: 260–278, 1930.

the lesion is very close to the crown in a region of living pith. Under no other circumstances has suberin been found in stems wounded as late as October.

While no growth responses are possible during the colder months the dying back of wounded stems continues even through the winter. During late autumn and early spring the unprotected junctions of these dead stems with the living crown are attacked by organisms which undoubtedly enter through the open hollow stubs. This infection leads to breakdown of tissue which extends into the crown and when spring growth is resumed the plants can not wall off these diseased parts. Consequently, as early as July the central region of the crown and the upper part of the tap root have largely decayed, leaving usually only a thin shell of living tissue. Such plants may look normal during the spring, but they are definitely less able to withstand the later periods of summer drought and nearly all of them die before autumn. In a general way these difficulties are commonly related to the hardships of the previous winter, but they go back instead to autumn injuries. The considerable time that elapses in red clover between the lesions of autumn and their effects the following summer has concealed the disastrous results of late wounding.

The nature of the pith on these legumes is a determining factor both with respect to the location of wound barriers and the promptness with which they are formed. In stems having solid living pith the cicatrice is developed quickly near the wound surface under the pseudocicatrice. But if there are dead or broken portions of pith the location of the barriers is necessarily shifted and stems die back to a plane of solid living pith. This long lag between injury and cicatrization is the critical period for red clover.

Since the summer of 1934 hundreds of clover fields throughout Iowa and neighboring states have been studied not only with respect to the immediate results of wounding, but also as to ultimate effects of cutting and pasturing. It is a common practice of long standing to clip or pasture red clover during the first fall after spring seeding. Careful check on large numbers of fields shows that there is a striking correlation between fall treatment and the percentage of infected plants at intervals during the following summer. These fields were selected at random from those having fair stands of clover and for which the cultural history could be obtained. A summary of these records shows, (1), that if the fields were heavily clipped during the late autumn the proportion of diseased plants during the following summer ranged from 50 to 95 per cent., and (2), that fields if left uninjured after the first of September had only 1 to 10 per cent. of infected plants by midsummer of the following year.

Apart from the effects of lesion, clover plants frequently die as a result of "winter-killing." This is especially true if crowns are exposed either by mowing or heavy pasturage late in the season. The death of such plants is undoubtedly caused by winter hazards other than those related to wounds. Nevertheless, it can not be stressed too strongly that late cutting or pasturing not only promotes this winter-killing, due to increased exposure as a result of removing plant cover, but, even if fields survive the winter, most of the plants inevitably suffer from crown infection the following growing season as a result of their inability to heal the wounds of the previous autumn.

It is not uncommon in eastern Iowa for entire fields of red clover to live through three growing seasons, and several cases are on record of four-year-old fields. But, in all the instances investigated where fields lived more than the second summer, the plants were neither cut nor pastured after the first of September and so went into the winter with considerable ground cover and with all wounds safely healed at or above the crown level.

It seems clear from study that in this region late-season treatment, apart from certain winter hazards, largely determines the fate of red clover in a given field.

ROBERT W. POULTER

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ROOTING NORWAY SPRUCE CUTTINGS WITHOUT CHEMICAL TREATMENT

AT the New Haven meetings of the New England Section of American Plant Physiologists, held on May 12 and 13, a method was described by which cuttings of 39-year-old Norway spruce trees were successfully rooted in large numbers during the past winter. Vegetative propagation of this economic forest and ornamental species permits establishing clones with desirable growth characteristics. One of our immediate objects will be the propagation of Norway spruce trees that have a natural immunity to the spruce gall aphid.

The results of the rooting tests were based on 3,200 cuttings collected at monthly intervals from October to January, inclusive. The factors tested included (1) month of collection; (2) length of cuttings, short (5 to 10 cm) and long (10 to 20 cm); (3) cuttings with and others without a heel of two-year-old wood; (4) no preliminary treatment, standing in water 24 hours or in indole butyric acid solutions with 2.5, 5, 10, 20, 40, 60, 80 and 100 mgms of the chemical per liter. The cuttings were planted in builders' sand in an open greenhouse bench with day temperatures around 70° F. and night temperatures never lower than 55° F. Analysis of the data is based upon the examination of the bases of the cuttings 14 weeks after planting.

Detailed analysis of the influence of the several factors investigated must await subsequent publication.

The two outstanding results appear to be, first, that the season at which the cuttings are taken governs to a large degree the percentage of rooting, and second, that treatment with indole butyric acid seems to retard rooting. The greater the concentration of this chemical the more rooting was retarded. In addition, long cuttings were superior to short cuttings and cuttings without heels rooted in greater numbers than those with heels. Placing the bases of the cuttings in tap water for 24 hours prior to planting in sand retarded rooting somewhat.

Terminal and lateral twigs of lateral branches located between six to eight feet from the ground were used when making the cuttings. Best rootage was secured from plain cuttings 10 to 20 cm long made in December and planted directly in the sand bench. In 14 weeks 90 per cent. of these cuttings were rooted. Both the December and January cuttings had larger roots and more advanced top development by May 1 than cuttings collected in October or November. In May more than a thousand rooted cuttings were planted in a tree nursery outdoors and in pots so that tests of their degree of immunity to spruce gall aphids could be conducted in the late summer.

CARL G. DEUBER
JOHN L. FARRAR

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PHYSIOLOGY OF THE NERVOUS SYSTEM

IN his painstaking appraisal of my book, "Physiology of the Nervous System," which appeared in SCIENCE for July 7 (the anniversary of its publication), Dr. Forbes has suggested that I deliberately omitted treatment of the nerve impulse and certain basic problems of neuromuscular transmission. The statement is true and lest misconception should arise from the review, it must be pointed out that the book deals primarily with the *central* nervous system, including the autonomic division. Dr. Ralph Gerard will describe the special physiology of peripheral nerve, *i.e.*, the nerve impulse and neuromuscular transmission, in a separate monograph of this series, which will appear in the near future. This will also deal with the principles of electrophysiology.

Since Dr. Forbes likewise offers a friendly accusation of prejudice with regard to the humoral theory of synaptic transmission, may I take this opportunity of stating once again that I know of no evidence fit for critical examination that would place the liberation of acetylcholine as a *primary* event essential for synaptic transmission, in any division of the nervous system, central or peripheral. The work of Rosenblueth and Simeone cited by Dr. Forbes was published after my book had left the press. A full statement of the evidence for the electrical concept of synaptic activity will appear in a series of five papers by Drs. Gasser, Erlanger, Bronk, Lorente de Nó and Forbes in the September number of the *Journal of Neurophysiology*, which is now in the press. It seems therefore unnecessary to offer here any further defense of my position in this interesting and important controversy.

Save for those points, which might mislead the uninformed reader, Dr. Forbes's review is fair, generous and much appreciated.

J. F. FULTON

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SCIENTIFIC BOOKS

The Distribution of the Stars in Space. By BART J. BOK, associate professor of astronomy, Harvard University. xvi + 124 pp. Chicago: University of Chicago Press, 1937. $2.50.

THE editors of the *Astrophysical Journal* are currently engaged in sponsoring a series of astrophysical monographs, which are designed to bring up to date the state of knowledge in the various fields of stellar astronomy. The first volume in the series, by Dr. Bok, is a critical exposition of the information available in 1937 on the distribution of the stars in the galactic system. A truly amazing number and variety of researches have been carried out in this field during the past fifteen years. To organize and discuss critically the results of these multitudinous investigations is an imposing task, and one which the author accomplishes with clarity and dispatch.

The fundamental problem of stellar statistics is to deduce the true stellar distribution in the galaxy from observational data on the apparent numbers, brightnesses, colors, spectral types and motions of the stars. Chapter I of "The Distribution of the Stars in Space" deals with the many statistical methods, both analytical and numerical, that have been devised for this purpose. Methods for detecting deviations from random stellar distribution in any area of the sky are valuable for promoting the discovery of inconspicuous dark nebulae. With regard to the problem of the determination of space densities, Dr. Bok discusses the relative merits of analytical and numerical methods and presents strong arguments in favor of the latter procedure. Simple analytical formulae are inadequate to represent the complex variations in stellar distribution over the sky. The most serious obstacle in the path of attaining a complete understanding of the details of stellar structure is the presence of clouds of obscuring material in the galaxy. The author describes how stellar statis-

ticians have been attempting to cope with this vexatious problem, with encouraging results.

Chapter II gives the present available sources of information on star counts, spectral types and the distribution of dark nebulae. A gratifying feature of Dr. Bok's discussion of the observational material is the manner in which he points out where new observations are most sorely needed. This feature, which is characteristic of the entire monograph, should prove highly stimulating to future research.

The third and final chapter deals with the general problems of galactic structure. Studies of the distribution of stars in directions perpendicular to the galactic plane are not complicated by the bogey of interstellar absorption, and considerable progress has been achieved in those directions, particularly by Oort. The author makes a critical survey of the arguments for and against the hypothesis of a local system of stars in which the sun is approximately central, and concludes that the hypothesis may at least be accepted as a working model. The monograph concludes on a highly optimistic note. Although only the most general features of galactic structure are now well established, Dr. Bok feels that the current rapid accumulation of observations will soon begin to reveal the finer details of stellar structure, and suggests that, as a working model, the galactic system may be regarded as a rather open spiral system, similar in form to Messier 33. On this basis, and accepting the hypothesis of a local system, the sun would be located in a spiral arm about two thirds of the distance from the center to one edge.

"The Distribution of the Stars in Space" is an extremely important contribution to the field of galactic structure, invaluable alike to both students and research workers in the field.

LEO GOLDBERG

THEORETICAL MECHANICS TREATED VECTORIALLY

Theoretical Mechanics, a Vectorial Treatment. By CARL JENNESS COE. New York: The Macmillan Company, 1938, 13 + 555 pages. Price, $5.00.

THIS text-book combines effectively an introduction to theoretical mechanics with training in the notation and methods of three-dimensional vector analysis (Gibbs's notation). Save for some words of caution in view of modern developments in relativity theory and quantum analysis, the selection of topics follows the classical tradition of such authors as Appell, Love, Routh, Webster and Whittaker. Rarely do mere physical facts intrude. Damped motion and sliding friction are touched upon, but the notions of elastic limit, atom, fluid, Young's modulus, oscillograph, viscosity or other commonplace terms of the physical laboratory find no place in this theoretical mathematical study. Included are chapters on the general principles of mechanics, on vector calculus and on potential theory (using three-dimensional vector calculus). But no attempt is made to introduce a generalized vector-space or tensor methods. Some prior training in calculus is assumed on the part of the student. An abundance of numerical exercises is provided which should give him facility and power in working with concepts which thereby can not but acquire clear significance.

ALBERT A. BENNETT

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SOCIETIES AND MEETINGS

THE ALABAMA ACADEMY OF SCIENCE

AT Montgomery, the capital, in the shadow of the spot where Jefferson Davis took the oath of office as president of the Confederacy, the Alabama Academy of Science held its sixteenth annual meeting, on April 14 and 15, with Huntingdon College as host. P. H. Yancey, of Spring Hill College, Mobile, presided. The historic background of this beautiful old southern "city of homes," together with the burst of bloom which is characteristic of the season, and the gracious hospitality of the college and of the Montgomery members, made this a memorable occasion. Eighty members, a number of visitors and over a hundred members of the Junior Academy, representing twenty-one schools, which met at the same time, registered. A certificate of award for the best paper and four certificates for the best exhibits in the various scientific fields were given the juniors by the senior academy. P. P. B. Brooks, head of the science department, Sidney Lanier High School, counselor at the place of meeting, assisted by James Holt Starling, head of the biology department, Troy High School, counselor to the president of the Junior Academy, had charge of arrangements for the Junior Academy, for which James H. Kassner, associate professor of chemistry, university, is acting permanent counselor.

Two symposia featured the program of the academy, which included forty-eight scientific papers, presented in four sections at Flowers and Bellingrath Halls and the Haughton Library on Friday afternoon and Saturday morning. Section I held a symposium on "The Biological Control of Malaria." This was presented by members of the health and safety department of the Tennessee Valley Authority, Wilson Dam, and the Alabama State Departments of Public Health and

of Conservation. Section II held a symposium on the "Chemistry of the T.V.A. Phosphate Fertilizers," given by the chemists of that division. Both created a great deal of interest and discussion.

The Academy Award from the American Association for the Advancement of Science was voted to J. Allen Tower, assistant professor of geography, Birmingham-Southern College, Birmingham, for "Preparation of an Atlas of Alabama and a Geography of Alabama." Birmingham-Southern College was selected as the next meeting place, the date to be set by the college in collaboration with the academy president.

Social features of the meeting included a tea for the visiting ladies at the home of Mr. and Mrs. E. D. Emigh. Other hostesses for this function were Mrs. Patrick H. Smyth, Mrs. Peter A. Brannon and Mrs. Haygood Paterson. The annual academy banquet was held at the Jefferson Davis Hotel on Friday night, with Haygood Paterson, commissioner of agriculture and industry, as toastmaster. The presidential address, "Science and the World Crisis," given by P. H. Yancey, featured the banquet. This was preceded by the address of welcome, made by Dr. Hubert Searcy, president of Huntingdon College, with response by Walter B. Jones, director of the State Department of Conservation. A motion picture, "The River," given through the courtesy of the National Park Service, closed the banquet, which was followed by an informal social in the ballroom of the hotel. On Saturday morning a geology field trip to old Fort Toulouse and Wetumpka was conducted by W. B. Jones and J. Y. Brame. Other attractions open to visitors were the State Health Laboratories, U. S. Weather Bureau, Montgomery Museum, and Seeing Montgomery Trip. Luncheon was served on both days at Pratt Hall, the college dining room.

Officers for 1939–1940 were elected as follows: *President,* George D. Palmer, associate professor of chemistry, University (elected last year); *President-elect,* C. M. Farmer, head of the biology department, State Teachers College, Troy; *Vice-Presidents and Chairmen of their respective sections:* Samuel Reed Damon, director of the Bureau of Laboratories, Alabama State Department of Health, Section I, Biology and Medical Sciences; Ingomar M. Hostetter, associate professor of mathematics, Howard College, Birmingham, Section II, Physics, Chemistry and Mathematics; A. J. Westland, seismologist, Spring Hill College, Mobile, Section III, Geology, Anthropology and Archeology; and E. D. Emigh, Weather Bureau, Montgomery, Section IV, Industry, Economics and Geography; *Editor of the Journal,* E. V. Jones, Birmingham-Southern College, re-elected for three years; councilor of the American Association for the Advancement of Science, J. H. Coulliette, professor of physics, Birmingham-Southern College, re-elected for one year. The treasurer, John Xan, head of the chemistry department, Howard College, has two more years to serve, and the secretary, Septima C. Smith, associate professor of zoology, University, has one more year.

An executive council meeting and a morning and afternoon business session, which disposed of routine business, were held on Friday. Three important new committees were approved for appointment by the president for expanding the personnel, influence and value of the academy to the members and to the state. These are: The Committee on the Promoting of Membership and the Activities of the Academy; the Committee on Research and the Publications Committee, an editorial board which is to assist the editor in furthering the quality of publications in the journal.

SEPTIMA C. SMITH

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SPECIAL ARTICLES

ISOLATION FROM BEEF PANCREAS OF A CRYSTALLINE PROTEIN POSSESSING RIBONUCLEASE ACTIVITY

A CRYSTALLINE protein which acts as a powerful digestive enzyme for yeast nucleic acid has been isolated from fresh beef pancreas. The digestion of the acid is accompanied by little, if any, release of inorganic phosphorus. The split products, unlike the undigested yeast nucleic acid, are not precipitable with glacial acetic acid or in 0.5 M hydrochloric acid. The products of digestion readily diffuse through collodion or Cellophane membranes that are impermeable for the undigested yeast nucleic acid. The nuclease activity of the crystalline protein is only very slowly diminished when boiled at pH 2.0. Boiling at pH 5.0 or higher brings about a gradual denaturation of the protein with a corresponding percentage loss of nuclease activity.

The nuclease activity of the new crystalline protein appears to correspond to the thermostable pancreatic nuclease activity described first by Jones[1] and later confirmed by Dubos,[2] Dubos and Thompson[3]

[1] W. Jones, *Am. Jour. Physiol.*, 52: 203, 1920.

[2] R. J. Dubos, SCIENCE, 85: 549, 1937. Dr. Dubos kindly tested the effect of the new crystalline material on the staining characteristic of two strains of Pneumococcus (heat killed). He found "that their staining characteristics are altered after a few hours incubation", like the material which he described,[3] the new crystalline protein "decreases the affinity of the bacterial cells for basic dyes" (personal communication from Dr. Dubos).

[3] R. J. Dubos and R. H. S. Thompson, *Jour. Biol. Chem.*, 124: 501, 1938.

and Schmidt and Levene.[4] The latter authors considered the thermostable pancreatic nuclease to have only a depolymerizing effect on nucleic acid without the production of Cellophane dialyzable products such as mononucleotides. Hence they named the enzyme "ribonucleodepolymerase." However, as mentioned before, the split products formed from yeast nucleic acid by the new crystalline protein were found to diffuse readily through collodion and Cellophane membranes; hence the more general term "ribonuclease" has been provisionally retained for this crystalline protein until more definite information becomes available about the chemical nature of the process.

The procedure for the isolation of the crystalline protein follows: Fresh beef pancreas is extracted with cold 0.25 N sulfuric acid, as described in the publications on the isolation of chymotrypsinogen and trypsinogen.[5] The acid extract is brought to 0.7 saturation with solid ammonium sulfate and filtered. The filtrate is then brought to 0.8 saturation with more ammonium sulfate and is refiltered with suction.

Crystallization: 10 gm of the semi-dry precipitate is dissolved in about 10 ml of water. The solution is filtered with the aid of about 0.5 gm of Standard Super-Cel (Celite Corporation) through soft filter paper on a small Büchner funnel; the residue on the paper is washed with water. The combined filtrate and washings are brought to a final volume of 20 ml. Saturated ammonium sulfate is then added slowly with stirring until a very faint turbidity appears. The pH of the solution is adjusted first to about pH 5.0 (brick red color with 0.01 per cent. methyl red solution on test plate) with the aid of a few drops of 1.0 N sodium hydroxide and then to pH 4.2 (orange color with 0.01 per cent. methyl orange) by means of 1.0 N sulfuric acid. The solution is allowed to stand at about 20° C. An amorphous precipitate rapidly forms. This changes within one or two days into a mass of fine needles or aggregates of long thin plates. The crystals are filtered after 2 or 3 days. The filtrate on further addition of saturated ammonium sulfate yields more crystals. The recrystallization is performed by adding saturated ammonium sulfate to an aqueous solution of the crystals until a very faint turbidity appears.

The crystalline material contains about 16 per cent. total nitrogen; 7 per cent. of the total nitrogen is free amino nitrogen. It does not diffuse through ordinary collodion membranes to any significant amount.

A solution of the crystalline material is precipitated completely in 10 per cent. trichloracetic acid and incompletely in 2.5 per cent. trichloracetic acid. It gives the usual protein color tests. The tyrosine-tryptophane content is about 15 per cent. of the total dry weight. The ribonuclease activity of the material becomes constant after the second crystallization.

Further investigation of the physical and chemical properties of the new crystalline protein and of the chemical changes brought about by its nuclease activity is in progress.

M. KUNITZ

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[4] G. Schmidt and P. A. Levene, *Jour. Biol. Chem.*, 126: 3, 1938.

[5] M. Kunitz and J. H. Northrop, SCIENCE, 78: 558, 33; 80: 505, 1934; *Jour. Gen. Physiol.*, 18: 433, 1935; : 991, 1936.

ISOSTERISM IN THE VITAMIN B COMPLEX

THE physiological effect of both nicotinic acid and thiamine is characterized by exceptional specificity. Numerous investigations in the recent literature show that even small changes in the loading of these two heterocycles greatly affect their physiological activity. It seemed of special interest, therefore, to investigate some isosters of these two vitamins.

The concept of isosterism as proposed by Grimm[1] and investigated by Erlenmeyer[2] and others has been applied with particular success to nuclear derivatives where ring sulfur and an aromatic –CH=CH– group are mutually replaceable. According to them a 3-substituted pyridine compound is isosteric with a 5-substituted thiazole compound. This permits consideration of a relation between nicotinic acid and thiamin which has hitherto been unsuspected.

We have found that thiazole-5-carboxylic acid, isosteric with nicotinic acid,[3] stimulates the growth of dysentery bacilli on Koser's synthetic medium.[4] Its activity is of the order of .1 per cent. of that of nicotinic acid. Its activity in curing black tongue in dogs has been investigated to some extent, but the results have been inconclusive.

2-methyl-3-β-hydroxyethyl-N-[(2-methyl-6-amino-pyrimidyl-(5))-methyl]-pyridinium bromide hydrobromide isosteric with Vitamin B_1 hydrobromide has been synthesized by condensation of 2-methyl-3-β-hydroxyethyl pyridine with 2-methyl-5-bromomethyl-6-amino pyrimidine hydrobromide. 2-methyl-3-acetyl pyridine was obtained from 2-methyl-3-cyanopyridine by a Grignard reaction. Bromination of the ketone followed by hydrolysis and Clemmensen reduction yielded the new 2-methyl-3-hydroxyethyl pyridine (picrate M.P. 129° uncorr.). Fed to a series of rats with medium or acute polyneuritic symptoms the new condensation product shows Vitamin B_1 activity. The experimental data do not as yet permit exact quantita-

[1] *Naturw.*, 17: 535–40, 557–64, 1929.
[2] *Helv. Chim. Acta.*, 16: 733–8, 1933.
[3] Erlenmeyer, *Helv. Chim. Acta.*, 20: 204, 1937.
[4] *Jour. Infectious Diseases*, 62: 212, 1938.

tive evaluation and suggest possibilities of modified action.

Further experiments are in progress.

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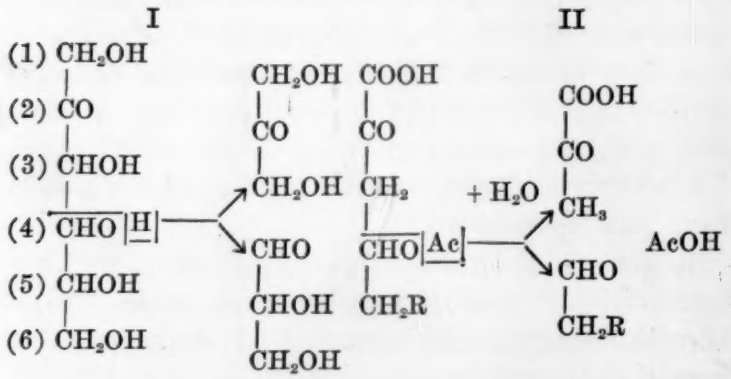
A REVERSED ALDOL CONDENSATION

DURING the past years many steps in the mechanism of glycolysis in muscle as well as in yeast have been cleared up. One of the remaining questions is: What causes the disruption of the easily fermentable hexose diphosphate ("primaeres Veresterungsproduct" of Meyerhof, etc.), to form two triose phosphates? Another open question is the position of the phosphoric acid rests in this hexose diphosphate. I would like to record an observation made a few years ago which may throw some light on these questions. Further work (which I am unable to undertake) is necessary to test whether this is a true or a false light.

The splitting of the hexose carbon chain to form two trioses is, chemically speaking, the reversal of an aldol condensation (I). I could observe a similar breakdown of a carbon chain in the case of α-keto γ-acetoxy acids. When incubating α-keto γ-acetoxy valeric acid [(II: R – H)] at 37° with water, the thick oil slowly dissolved within a few days and pyruvic acid, acetic acid and acetaldehyde could be isolated and identified in form of derivatives. The next higher homologue [(II: R – CH_3)] gave the same decomposition, while aldol, acetaldol, β-acetoxybutyric



acid and β-acetoxy δ-keto-pentane were quite stable under these conditions. It appears that an acid pH of the solution or an acid group in the molecule is an essential condition for this breakdown, as well as an oxo-group in β-position to an esterified alcoholic one; this latter alcoholic group forms the new aldehyde group after the rupture of the chain. In analogy one is tempted to suppose that the readily fermentable hexose diphosphate ("primaeres Veresterungsproduct") is a ketose, carrying one phosphoric acid group in position 4. This might weaken the C–C-link between carbon atoms 3 and 4 sufficiently to cause a spontaneous formation of two trioses under our experimental conditions and the zymohexase might only be needed to catalyze this reaction to proceed with the necessary speed.

HEINZ FRAENKEL-CONRAT

THE PRODUCTS OF THE CYCLIZING DEHYDRATION OF 1-BETA-PHENYLETHYLCYCLOHEXANOL-1 AND THE SYNTHESIS OF SPIROCYCLOHEXANE-1,1-INDANONE-3

BY a cyclizing dehydration of 1-*beta*-phenylethylcyclohexanol-1 with 85 per cent. sulfuric acid, Perlman, Davidson and Bogert[1] observed the simultaneous formation of octahydrophenanthrene and spirocyclohexane-1,1-indane.

Recently, Cook, Hewett and Lawrence,[2] and Cook, Hewett and Robinson,[3] by cold oxidation with chromic acid of a glacial acetic acid solution of the mixture of hydrocarbons resulting from the cyclization of *beta*-phenylethylcyclohexene-1, obtained a mixture of ketones, which they converted into the corresponding oximes, and then separated the latter by fractional crystallization. They thus isolated three oximes, which melted, respectively, at 187.5°, 175–177° and 124°. The first of these, they believed to be the oxime of spirocyclohexane-1,1-indanone, the second that of the *trans*-ketoöctahydrophenanthrene, and the third (m.p. 124°) that of its *cis*-isomer.

We have been occupied lately in the synthesis and study of the pure spirocyclohexane-1,1-indane, to learn more about its behavior when subjected to dehydrogenation reactions, and how its monacetyl derivative compares with those of the *cis*- and *trans*-octahydrophenanthrenes reported by Van de Kamp and Mosettig.[4]

In the course of this investigation, we synthesized the spirocyclohexane-1,1-indanone (VI), and found that its oxime melted at 137–137.8° (corr.). This wide divergence from the melting-point of 187.5° recorded by Cook *et al.* for their oxime, led us to reinvestigate the aforementioned hydrocarbon mixture, by a procedure essentially identical with that of our English colleagues with the result that we isolated the following oximes:

(1) An oxime, m.p. 187–188° (corr.).

(2) An oxime, m.p. 136.5–137° (corr.), which m.p. was not depressed when the compound was mixed with the oxime (m.p. 137–137.8°, corr.) of our synthetic spiroketone (VI). Each oxime was nitrated separately in cold concentrated sulfuric acid with powdered pota-

1 Perlman, Davidson and Bogert, *Jour. Org. Chem.*, 1: 288, 300, 1936. See also Perlman and Bogert, *Jour. Am. Chem. Soc.*, 59: 2534, 1937.

2 Cook, Hewett and Lawrence, *Jour. Chem. Soc.*, 1936, 71.

3 Cook, Hewett and Robinson, *ibid.*, 1939, 168.

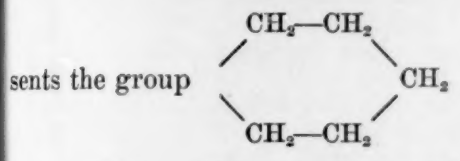
4 Van de Kamp and Mosettig, *Jour. Am. Chem. Soc.*, 58: 1062, 1936.

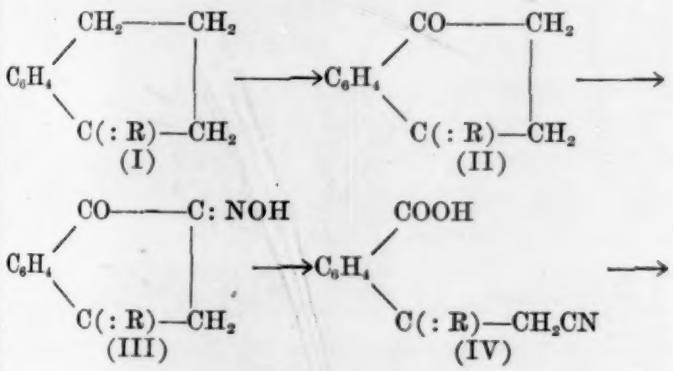
sium nitrate, and the nitro oximes were then hydrolyzed with dilute sulfuric acid. The nitro ketones so obtained were identical and both melted at 192° (corr.). Further, direct nitration of our synthetic spiroketone (VI) gave the same nitro ketone (m.p. 192°, corr.).

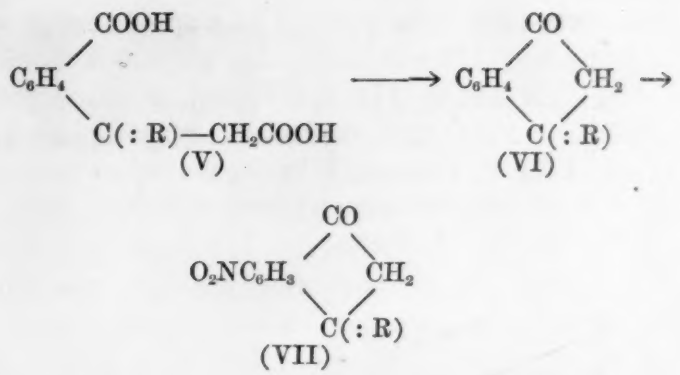
(3) An oxime, m.p. 123–124° (corr.), which yielded a nitro ketone, m.p. 149–150° (corr.). This is evidently the same as the oxime, m.p. 124°, whose nitro ketone melted at 150–150.5°, and which Cook *et al.* suggested was probably the oxime of the *cis*-ketoöctahydrophenanthrene.

The only difference between our operations and those of Cook *et al.* was that our mixture of hydrocarbons was obtained by the action of 85 per cent. sulfuric acid upon the phenylethylcyclohexanol, while theirs was the result either of the action of phosphorus pentoxide upon the cyclohexanol, or of aluminum trichloride upon the corresponding cyclohexene.

The spirocyclohexane-1,1-indanone (VI) was synthesized by the following steps, in which "R" represents the group







The pure spirocyclohexane-1,1-indanone (VI) was obtained as a white crystalline solid, m.p. 58–59° (corr.); oxime, m.p. 137–137.8° (corr.).

All products described in the foregoing gave on analysis figures substantiating the formulas assumed.

SUMMARY

(1) Spirocyclohexane-1,1-indanone (VI) has been found among the oxidation products of the hydrocarbon mixture which results when 1-*beta*-phenylethylcyclohexanol-1 is dehydrated, or when 1-*beta*-phenylethylcyclohexene is cyclized by aluminum trichloride, and its constitution has been proved by synthesis.

(2) Its oxime melts at 137–137.8° (corr.). The oxime of m.p. 187.5°, reported by Cook *et al.* therefore must be derived from some other ketone, perhaps the trans-ketoöctahydrophenanthrene, since we were unable to isolate any oxime of m.p. 177°, the figure which they reported for this compound.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN X-RAY DENSITOMETER FOR MEASURING RELATIVE DENSITIES OF MUSCLE, BONE AND OTHER TISSUES

IN the studies of child growth and development undertaken by the Developmental Health Inquiry of the Associated Foundations it became evident that an objective method for measuring muscle, bone and other tissue densities would be a valuable aid. An x-ray densitometer has been designed and constructed for that purpose and is now in use.

Two other x-ray densitometers have recently been reported, one by P. B. Mack,[1] which is being used at Pennsylvania State College to determine the degree of mineralization of bone in a nutritional study and one by R. G. Bloch,[2] at Chicago University, designed for a study of tuberculous calcifications. Although the apparatus described here is similar in principle to these, its differences are the result of an attempt to obtain an optimum degree of accuracy combined with rapidity of operation and simplicity in interpretation of readings in a unified portable instrument.

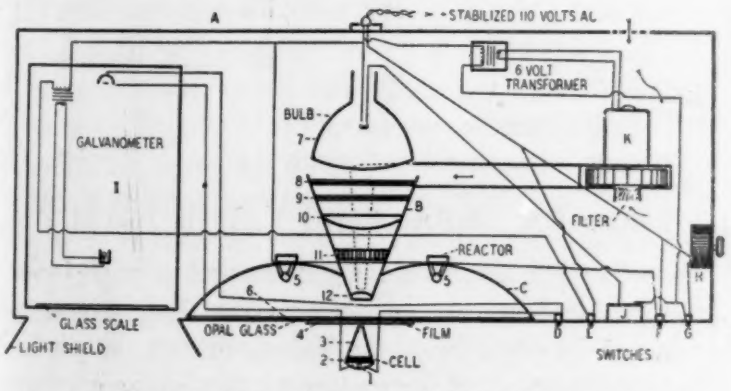

FIG. 1. Top view and circuit diagram.

As shown in Fig. 1, the various components of the

[1] P. B. Mack *et al.*, SCIENCE, 89: 467, 1939.
[2] R. G. Bloch *et al.*, *Am. Jour. of Roentgenol. and Rad. Therapy*, 41: 642–647, 1939.

instrument have been mounted in a special metal case (A) and only 110-volt alternating current is required.

The light source (7) for density measurement is centered in a new type vertical x-ray illuminator (C). Controls (D, E, F, G and H) are grouped on the right-hand panel, and the galvanometer (I) is in the same case to the left. A vertical arm (1) mounting a photo-E.M.F. cell (2) for measuring the light transmitted by any square mm area of film is hinged to turn out of the way while the illuminator is used for other purposes. A brass cone (3) with its interior surface chromium-plated and a 1 mm circular opening at the apex is fitted over the cell. The film (4) is held in place by hinged rubber-tipped arms and can be moved freely to place any desired portion under the cone aperture for density measurement. In the new x-ray illuminator mentioned above, two 18-inch tubular fluorescent bulbs (5) in the special reflector (C) provide a cold blue light for the flashed opal glass (6).

A 150-watt floodlight bulb (7) in the optical system is directed toward the large end of an aluminum cone (B) which contains two glass filters (8, 9), two condensing lenses (10, 12) and a disc of lucite (11), to project an intense spot of cool monochromatic light on the opal glass. A rheostat (H) and voltmeter (J) in the bulb circuit provide a control for intensity of the spot, and a voltage regulator is employed to reduce line voltage variations to ± 1 per cent. at all values. Heat generated by the bulb in the optical system is dissipated by well-directed streams of filtered air from a rotary fan (K), thus keeping the temperature rise at the film to 9° C. above room temperature under the most intense light. Cell output current is registered on the sensitive portable galvanometer (I) of reflected-beam, enclosed-spotlite type.

A calibration table has been made which permits relative tissue density values, based on absolute film densities, to be noted at a glance for each millimeter of galvanometer deflection. Effects of variations in exposure time, developing and emulsion are suppressed by subtracting the reading for a standard film area from each other reading on that film. The total range of the instrument in units of film density is from 0.3 to 3.0, which includes all the x-ray films in our files.

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METHOD OF EMBALMING LARGE INSECTS[1]

ANY one who has mounted numbers of grasshoppers or other large insects appreciates the difficulties encountered in drying the specimens without deterioration, discoloration or destruction by the larvae of flies.

[1] Contribution No. 205 from the Department of Zoology, University of Oklahoma, Norman.

The following technique was devised by the writer to improve the quality of dried insect specimens by eliminating the difficulties mentioned above. Although the method is original as far as the writer is concerned, others may have suggested similar procedures.

An embalming fluid is prepared as follows:

60 ccs of toluene (or xylene)
25 ccs of tertiary butyl alcohol
15 ccs of ethyl alcohol
5 grams phenol
20 grams paradichlorbenzene
10 drops of balsam in xylene as used in microtechnique

Mix the ingredients in the order named.

The fresh specimen is injected by inserting the needle of a hypodermic syringe in a posterior abdominal segment and running it forward to or into the head, then slowly withdrawing the needle while injecting the fluid. Care should be taken not to force too much fluid into the body cavity at once, as the abdominal segments may be ruptured. After injection, lay the specimen aside a few moments, then pin it in position on a drying board and place in an open place for twenty-four or more hours.

The writer has found that the largest grasshoppers will ordinarily dry in less than forty-eight hours following this treatment. No color changes occur in the injected specimens.

The fluid may also be used as a preservative without injection by merely dropping the specimens into a jar and covering with the liquid. Green-colored grasshoppers bleach somewhat if stored in the fluid. I have other specimens which were stored in the fluid for over a year, then dried, which show very little color change.

Museum pests, mice and flies are effectively repelled by this treatment.

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